Black than White children who live in poverty (41 per cent versus 11 per cent in 1978).[10]

Our finding of higher blood lead levels associated with lower education, lower income, and increased proportion of single parent families emphasizes the need to continue screening efforts in the lower socioeconomic areas with older housing. Further research into non-traditional sources of lead exposure and intervening factors is indicated.

REFERENCES

1. Public Law 91-695, January 13, 1971, 91st Congress, HR 19172.
2. Enterline PE, Waller J, Henderson *et al*: Final Report on Planning Grant to Evaluate Blood Lead Data for Children. Washington, DC: National Bureau of Standards 6-9004, 1977.
3. Stark AD, Meigs JW, Fitch RA: Family operational co-factors in the epidemiology of childhood lead poisoning. Arch Environ Health Sept/Oct 1978; 33:222–225.
4. Keenan RG, *et al*: USPHS method for determining lead in air and biological materials. Am J Ind Hyg 1963; 24:481–91.
5. Hessel DW: A simple and quantitive determination of lead in blood. Atomic Absorption Newsletter 1968; 7:55.
6. US Bureau of Census: Detailed Demographic Characteristics of Detroit SMSA Census Tracts, 1970. Washington, DC: Census Bureau, 1970.
7. Ingalls TH, Tiboni EA, Werrin M: Lead poisoning in Philadelphia. Arch Environ Health 1961; 3:575–579.
8. Jacobziner H: Lead poisoning in childhood: epidemiology, manifestations and prevention. Clin Pediatrics 1966; 5:277–286.
9. Christian JR, Celewyzc BS, Andelman SL: A three-year-study of lead poisoning in Chicago. Am J Public Health 1964; 54:1241–1251.
10. Report of the Select Panel for the Promotion of Child Health; 1980: Better Health for our Children: A National Strategy. III. A Statistical Profile. Washington, DC: US Department of Health and Human Services.

A Brief Review of the Current Status of Alternatives to Chlorine Disinfection of Water

A. C. ANDERSON, R. S. REIMERS AND P. DEKERNION

Abstract: This paper briefly outlines some of the alternative disinfectants being considered in lieu of chlorination. Methods currently in use as well as those in the research stage are included. Each method is assessed with respect to disinfection efficiency and environmental impact. (*Am J Public Health* 1982; 72:1290–1293.)

Introduction

Chlorine is currently being reevaluated as the standard for disinfection of drinking water and wastewater. Alternative methods are being sought due to the cost of manufacture of hypochlorite, its potential carcinogenic effects,[1] mutagenic effects,[2] toxicity to aquatic species,[3,4] and explosive properties.[5] Among the most promising chemical alternatives are chlorine dioxide and ozone.

From the Department of Environmental Health Sciences, Tulane University. Address reprint requests to Ann C. Anderson, PhD, Associate Professor, Environmental Health Sciences, School of Public Health and Tropical Medicine, Tulane University, 1430 Tulane Avenue, New Orleans, LA 70112. This paper, submitted to the Journal March 10, 1982, was revised and accepted for publication May 13, 1982.

Chlorine Dioxide

Approximately 85 water treatment plants in the United States currently use chlorine dioxide for disinfection, and for removing iron, manganese, taste, odor and color. In Europe, approximately 495 plants use the compound for disinfection and as an oxidant residual.[6]

Chlorine dioxide effectively destroys coliforms, enteroviruses,[7] and pathogenic amoebae.[4] It is a stronger oxidant than chlorine and also provides a longer residual in potable water. When chlorine is absent from water, chlorine dioxide does not react with ammonia or aromatic organics and does not produce trihalomethanes.[9] It is also less likely than chlorine to form chlorinated organics.[6] Disadvantages of chlorine dioxide include its cost and production problems. In the generation of chlorine dioxide, free chlorine, chloramines, and traces of chlorite and chlorate are produced. Ammonia is generally added to the feed water to combine with free chlorine to produce chloramines and prevent the formation of trihalomethanes. However, if excess chlorine is present, trihalomethanes are formed.[9] Both chlorite and chlorate can oxidize hemoglobin resulting in methemoglobin and reduced oxygen carrying capacity. Chlorite is a hemolytic agent and may initiate hemolytic anemia in susceptible individuals at the levels found following disinfection.[10]

Ozone

Since the first ozonation plant was constructed in 1893, over 1,000 plants have been built throughout the world.[6] In

TABLE 1—Alternative Disinfectants—Advantages and Disadvantages

Advantages	Disadvantages
Chlorine Dioxide	
Effective against many microbes.	Cost.
More effective than chlorine over short contact.	Chlorine, chlorite, chlorate are formed in production. With excess chlorine, trihalomethanes are formed.
Strong oxidant, long residual.	Chlorite and chlorate oxidize hemoglobin. Chlorite is a hemolytic agent.
Good taste, odor, color control.	More data on acute and chronic effects of the production by-products needed.
Iron, manganese removal.	
Not reactive with ammonia or aromatic organics to yield trihalomethanes.	
Forms chlorinated organics less readily than chlorine.	
Ozone	
Strong oxidizing agent.	No residual effect.
Good color, taste, odor control.	Organic reaction products largely unknown.
No trihalomethanes formed. Can oxidize trihalomethane precursors.	Epidemiology of ozone effects in potable water not available.
With U.V. can remove pesticides, PCB's (high concentrations and contact time needed).	
Effective against a variety of microbes.	
Improves flocculation and settling.	
Bromine Chloride	
All advantages of chlorine.	All disadvantages of chlorine.
More reactive than chlorine on microbes.	Brominated organics formed generally more toxic than chlorinated organics—but are more unstable.
Bromamines formed are more effective than chloramines for microbe removal.	More data needed on environmental effects.
Ultraviolet Light	
Effective against many microbe types.	Penetration capacity through water limited.
No chemical by-products or toxics.	Color, turbidity, organics can reduce potential.
	UV harmful to eyes, skin.
	No residual effect.
Ultrasonics	
Effective against many microbe types.	Thick films of water attenuate sound and reduce effectiveness.
Increases settling rate of activated sludge and mixed liquor.	Cost.
Aids in hardness removal.	

the United States, there are approximately 52 plants under construction or in operation.

Ozone is a strong oxidizing agent and reacts with a wide variety of organic compounds. Ozone can oxidize trihalomethanes in the presence of ultraviolet light,[6] does not form trihalomethanes in water,[11] and can also remove trihalomethane precursors.[12] Ozone is also effective in controlling taste, odor, color, and algae and for removing bacteria,[13,14] amoebae,[8] and viruses.[15]

Since ozone is labile, there is little concern about its health effects or the inorganic reaction products that might be formed.[16] The organic reaction products, however, are still largely unidentified, although aldehydes, hydrocarbons, and simple organics have been isolated.[16,17]

The lack of information on these reaction products and their toxicity is, perhaps, the major concern regarding ozonation. Although ozonation has been practiced extensively in Europe for many years, epidemiological information on its effects in potable water is not available.[16] Since ozone does not provide a residual, it must be used in combination with another disinfectant to protect the distribution system.

Bromine Chloride

Since bromine chloride is a complex of two halogens, it has all of the advantages of chlorine as a disinfectant and oxidizing agent. Bromine chloride is more reactive than chlorine for inactivating enteric viruses[18] and coliforms in wastewater.[19,20] When hypobromous acid and ammonia react, bromamines are formed. The bromamines are more effective than chloramines for both bacterial and viral removal.[1] The residual bromamines are less stable in water than chloramines and convert to bromide salts.

There are, however, disadvantages to the use of bromine chloride. Chlorine is still present, with all of its disadvantages and the brominated organics formed are generally more toxic than their chlorinated counterparts. However, because they are unstable, toxicity to aquatic life appears to be similar to that of chlorine.[1,21] In general, more testing is necessary on the human and aquatic toxic effects before bromine chloride can be fully utilized as an alternative disinfectant.

Ultraviolet Light

The disinfecting potential of ultraviolet (UV) light has been known for many years. With recent advances in UV equipment design, treatment on a large scale is becoming feasible. There are currently 14 wastewater treatment plants funded by the Environmental Protection Agency in the United States.

Ultraviolet light has proven effective against many microorganisms but varies with microbe type. A more intense dose is required to inactivate bacterial and fungal spores and protozoa than is required for vegetative bacterial cell distruction.[22,23] Ultraviolet light is also effective against viruses with a fourfold reduction in viral concentration shown in wastewater treatment plants using UV disinfection.[24]

Ultraviolet irradiation does not effect non-volatile chemical constituents of waste streams. The lack of chemical by-products and toxic residues may be one of the most important aspects of this emerging alternative disinfectant.[13]

There are disadvantages to UV. The penetrating capacity is limited, requiring thin films of water through the process unit. In addition, color, turbidity, organics, and iron salts can reduce disinfection potential. Voltage changes and temperature fluctuations also may reduce UV lamp intensity.[25] There is also the potential for occupational exposure to UV irradiation which is harmful to the eyes and skin. Because UV produces no residual, it must be used in tandem with a method that maintains germicidal activity throughout the distribution system.

Ultrasonics

Ultrasound is also becoming an important alternative to chemical disinfectants. A wide range of microbes are subject to the lethal effects of sonication including bacteria, yeasts,[26] and Ascaria.[27] Ultrasonication increases the settling rate of both activated sludge and mixed liquor, especially when ferric chloride is added.[28] It also contributes to hardness removal by precipitating calcium and magnesium oxides.[26]

While ultrasound is an effective disinfectant, there are disadvantages. Thick films of water attenuate the sound waves and thereby reduce effectiveness. Ultrasound is also relatively expensive, being approximately 15 times the cost of chlorination, based on 1976 figures.[1,26]

Induced Field Processes

These processes involve passing fluid through an electrostatic or electromagnetic field. There has been much controversy over these processes, with mixed reports in the literature as to their effectiveness.[29,30] Recent research findings, however, indicate electrostatics to be a viable process for water treatment, for reducing boiler scale and corrosion,[31,32] and for reduction of bacteria and viruses.[26,27]

Summary

In summary, several chemicals are being investigated in lieu of chlorine for disinfection. Viable alternatives include chlorine dioxide, bromine chloride, and ozone. These chemicals are more expensive but still competitive with chlorine. Aquatic toxic effects are generally assumed lower than for chlorine. Among non-chemical disinfectants, ultraviolet light and sonication are being explored. The advantages and disadvantages of each method are reviewed in Table 1.

REFERENCES

1. Hais A: Disinfection of Wastewater Task Force Report. EPA-430/9-75-012, 1976.
2. Rapson WH, Nazar MA, Butsky VV: Mutagenicity produced by aqueous chlorination of organic compounds. Bull Env Contam Tox 1980; 24:590–597.
3. Ward RW, DeGraeve GM: Acute residual toxicity of several disinfectants in domestic and industrial wastewater. Water Res Bull 1980; 16:48.
4. Scott GI, Middaugh DP, Crane AM, McGlothin N, Watabe N: Physiological effects of chlorine produced oxidants and uptake of chlorination by-products in the American oyster, Crassostrea virginia (Gmelin). Water Chlor Env Impct Hlth 1980; 3:501.
5. Chemistry Laboratory Safety Library, 491M, 5th ed. Boston: Natl Fire Protect Assn, 1975.
6. Miller GW, Rice RG, Robson CM, Scullin RL, Kuhn W, Wolf H: An Assessment of Ozone and Chlorine Dioxide Technologies for Treatment of Municipal Water Supplies. EPA-600/8-78-018, 1978
7. Scarpino PV, Cronier S, Zink ML, Brigano FAO, Hoff JC: Effect of particulates of disinfection of Enteroviruses and coliform bacteria in water by chlorine dioxide. Proc AWWA Technol Conf 1977; V 2B-3, 11.
8. Cursons RTM, Brown TJ, Keys EA: Effect of disinfectants on pathogenic free living amoeba in axenic conditions. Appl Env Micro 1980; 40(1):62.
9. Vogt C, Regil S: Controlling trihalomethanes while attaining disinfection. *In:* Water Disinfection with Ozone, Chloramines or Chlorine Dioxide. Proc AWWA Sem 20152, 1980.
10. Bull AJ: Health effects of alternative disinfectants and their reaction products. JAWWA 1980; 72:5, 299.
11. Kuhn W, Sontheimer H, Steiglitz L, Maier D, Kurz R: Use of ozone and chlorine in water utilities in the Federal Republic of Germany. JAWWA 1978; 70(6):326.
12. Trussell RR, Umphies MD: Formation of trihalomethanes. JAWWA 1978; 70(11):604–610.
13. Jolley RL, Lee NE, Pitt WW, Denton MS, Thompson JE, Hartmann SJ, Mashni CI: Effects of chlorine, ozone and ultraviolet light on nonvolatile organics in wastewater effluents. *In:* Venosa AD (ed): Progress in Wastewater Disinfection Technology 1979; EPA-600/9-79-018.
14. Donald DA, Gould JP: Preliminary results of ozone disinfection of seawater containing potential shrimp pathogens Vibrio spp. and Fusarium solani. Ozone: Sci Eng 1980; 1:329.
15. Kim CK, Gentile DM, Sproul OJ: Mechanism of ozone inactivation of bacteriophage f2. Appl Env Micro 1980; 39:210.
16. Greenberg AE: Public health aspects of alternative water disinfectants. *In:* Water Disinfection With Ozone, Chloramines or Chlorine Dioxide. Proc AWWA Sem 20152, 1980.
17. Kuo PPK, Chian ESK, Chang BJ: Identification of end products resulting from ozonation and chlorination of organic compounds commonly found in water. ES&T 1977; 11(13):1177.
18. Keswick BH, Fugioka BS, Loh PC, Burbank NC: Comparative disinfection by bromine chloride and chlorine of viruses and bacteria in wastewater. JWPCF 1980; 52(10):2581–2587.
19. Longley KE, Moore BE, Sorbar CA: Comparison of chlorine and chlorine dioxide as disinfectants. JWPCF 1980; 52:2098.
20. Aieta EM, Berg JD, Roberts PV, Cooper RS: Comparison of

chlorine dioxide and chlorine in wastewater disinfection. JWPCF 1980; 52(4):810–824.
21. Ledin LH, Burton DT, Bongers LH, Holland AF: Effects of chlorobrominated and chlorinated cooling waters of estuarine organisms. JWPCF 1981; 52:173.
22. Donnellan JE, Stafford RS: The ultraviolet photochemistry and photobiology of vegetative cells and spores of *Bacillus megaterium*. Biophysiol J 1968; 8:17–28.
23. Gaudy A, Gaudy E: Microbiology for Environmental Scientists and Engineers. New York: McGraw Hill, 1980.
24. Fluegge RA, Metcalf TG, Wallis C: Virus inactivation in wastewater effluents by chlorine, ozone and ultraviolet light. *In:* Venosa AD (ed): Progress in Wastewater Disinfection Technology. EPA-600/9-79-018, 1979.
25. Cheremisinoff NR, Cheremisinoff PN, Trattner RB: Chemical and Non-Chemical Disinfection. New York: Ann Arbor Pub, 1981.
26. Horton JP, Horwood MP, Phynney DE: Application of the lethal properties of ultrasound to sanitary engineering practice. Sew Indust Waste 1951; 24:457.
27. Reimers RS, deKernion PS, Anderson AC, Lo CP, Leftwich DB, White LE: Evaluation of ultrasonics and electrostatics in the bioinactivation of bacteria and parasites. Proc. II Water Reuse Sym. AWWA in press, 1982.
28. Lyons WA: The effect of ultrasonics on suspended matter in sewage. Sewage Indust Waste 1951; 23(9):1084.
29. Eliassen R, Skrinde PT, Davis WB: Experimental performance of "miracle" water conditioners. JAWWA 1958; 50:1371–1384.
30. Dearborn Chemical Division of Chemed Corp: Watch out for a new round of water treatment "gadgets". Water Conditioning July, 1977.
31. Joshi KM, Kamat PV: The effect of magnetic fields on the pH of water. J Ind Chem Coc, 1966, p 43.
32. Kirgintsev AN: Mechanisms of the magnetic treatment of liquids. Zh Fiz Khim 1971; 45(4):857–859.

Social and Contextual Factors in the Analysis of Mortality in End-Stage Renal Disease Patients: Implications for Health Policy

ALONZO L. PLOUGH, PHD, MPH, AND SUSANNE SALEM, MHSA

Abstract: A sample of medical records of deceased End-Stage Renal Disease (ESRD) patients was reviewed by a panel of experienced clinicians. The panel's determination of cause of death was compared to that reported for these patients in the Health Care Financing Administration Management Information System. There was concurrence in only 25 per cent of the cases. The difference is attributable to increased awareness of psychosocial and behavioral antecedent factors surrounding the occurrence of death. (*Am J Public Health* 1982; 72:1293–1295.)

Introduction

In 1973, End-Stage Renal Disease (ESRD) became the first and only catastrophic illness for which the federal government pays treatment costs (through Medicare) for nearly all persons, both under and over the age of 65. Over 50,000 persons are treated in this program at the present time employing different treatment modalities (hemodialysis, peritoneal dialysis, and transplantation) in a variety of settings (hospital, freestanding facility, home). These treatments do not cure the condition but offer a prolongation of life of varying duration depending on a variety of factors, including clinical, sociodemographic, and psychosocial dimensions.[1-3]

Major questions need to be addressed relating escalating costs and outcomes of care delivered to ESRD patients with the type of treatment modality chosen and the type of facility providing care. These are complex issues necessitating comprehensive data on mortality and morbidity associated with ESRD.[4]

The Health Care Financing Administration collects such data through the ESRD Medical Information System (MIS). Reporting completeness ranges from a low of 20 per cent to a high of 70 per cent of patients.[5] Developing effective program policies demands an understanding of the causes of poor survival. This paper addresses the issue of cause of death in a treated ESRD population. Our particular concern is whether the federal data accurately represent the context of mortality in this important chronic illness, rather than reflecting only proximate clinical correlates.

Materials and Methods

The patients to be studied included all ESRD patients treated at a large New England teaching hospital who died between 1972 and 1978 (N = 50). Those for whom complete medical records could not be found were excluded from the sample, leaving a sample size of 40 with substantial social

Address reprint requests to Alonzo L. Plough, PhD, Associate Professor, Department of Urban and Environmental Policy, Tufts University, Medford, MA 02155. This paper, submitted to the Journal December 2, 1981, was revised and accepted for publication May 13, 1982.